Storage Ring EUV Light Source Based on Steady State Microbunching Mechanism

The SSMB Collaboration

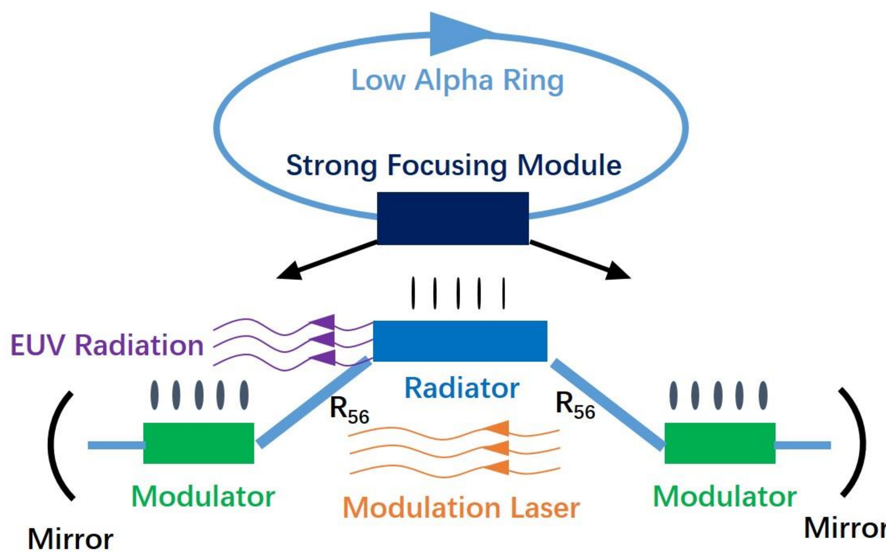
Tsinghua University

2018 EUVL Workshop

Abstract

An initial task force has been established in Tsinghua University to design an electron storage ring to generate kW level EUV radiation based on the steady state microbunching (SSMB) mechanism [1]. In this poster, the basic idea of SSMB as well as the potential advantages of applying it for EUV lithography are briefly introduced. The main tasks of the collaboration at this moment, which consist of the dedicated EUV SSMB lattice design, the effort to address related technical challenges and the preparation of proof-of-principle experiment, are then presented.

SSMB



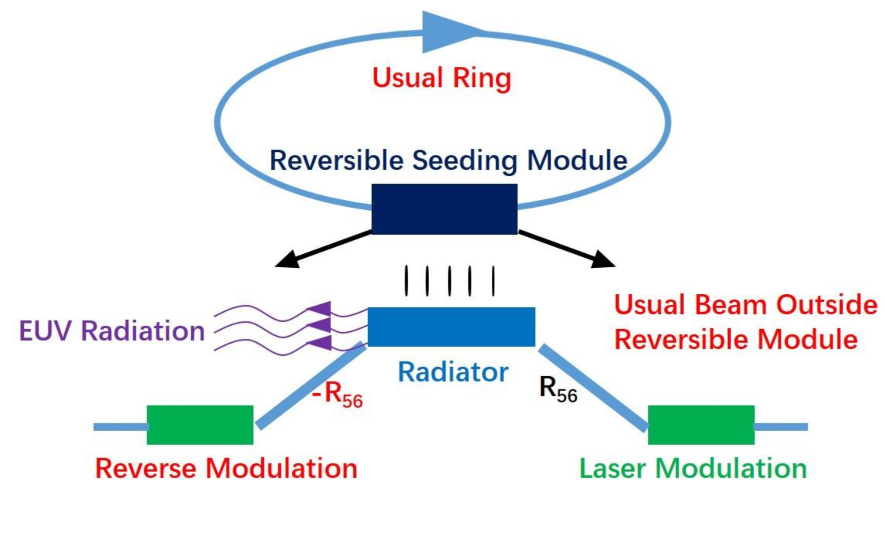
Longitudinal strong focusing SSMB.

Key points of SSMB:

- Microbunching: the microbunches radiate coherently $P_{rad} \propto N^2_{coherent}$, leading to a high peak power;
- Steady-state: beam parameters preserve turn-by-turn after radiation, resulting in a high repletion rate;

These two features combined is the high power source of SSMB.

SSMB is a general concept and there are several specific scenarios. The collaboration now focuses on the longitudinal strong focusing and reversible seeding schemes.



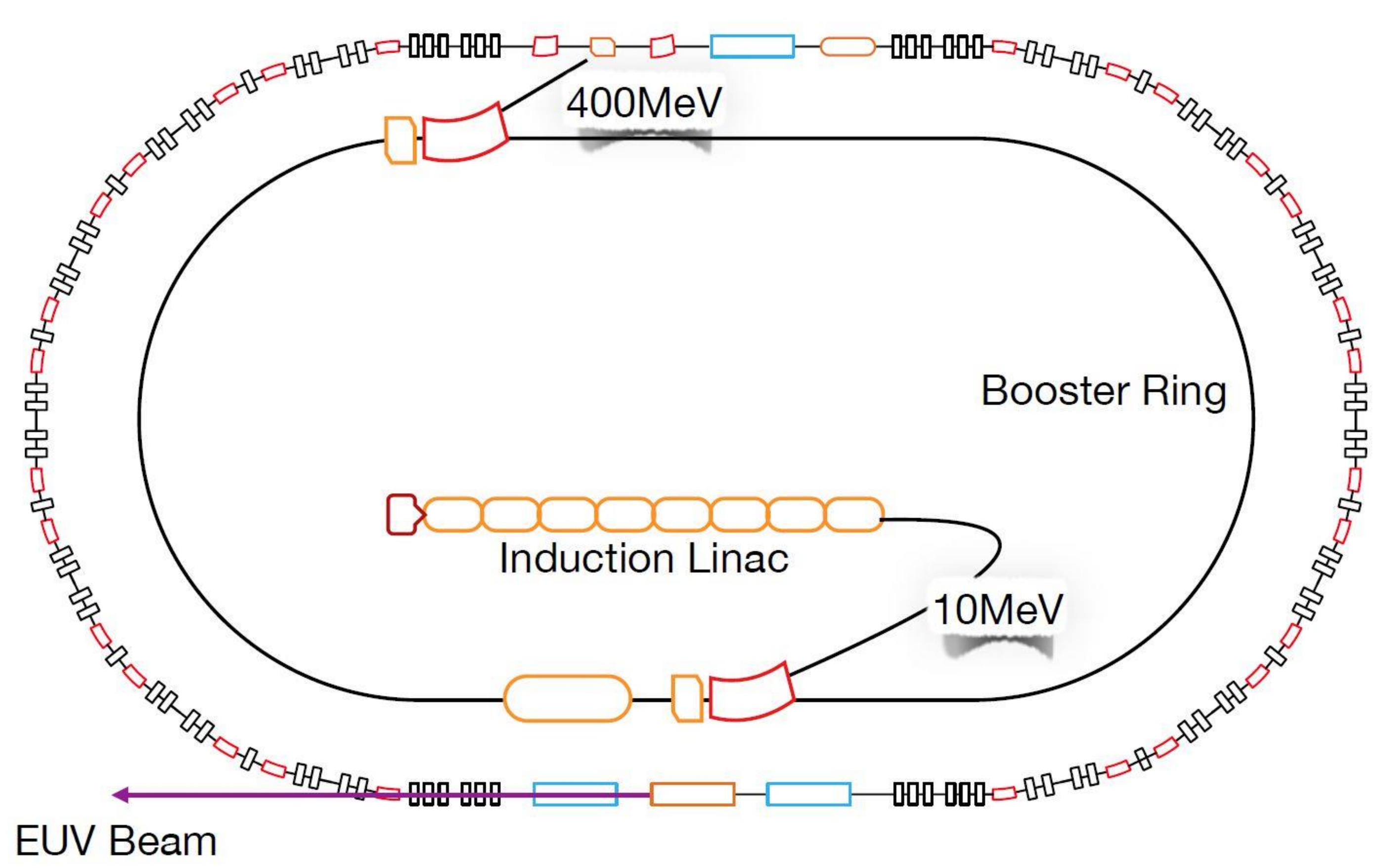
Reversible seeding SSMB.

Potential Advantages of Using SSMB for EUV Lithography

- High average power: the power aimed is >1kW per tool, each facility should be able to incorporate multiple tools.;
- Truly continuous wave: the temporal structure of the radiation is truly CW, this minimizes the chip damage problem;
- Narrow banded: the radiation frequency bandwidth is $< 1\%$;
- Collimated: the radiation has a well collimated angular spread $\lesssim 0.1$ mrad;
- Clean radiation: the radiation is clean and carries no debris, so that mirrors do not get contaminated and do not require frequent replacements during operation.

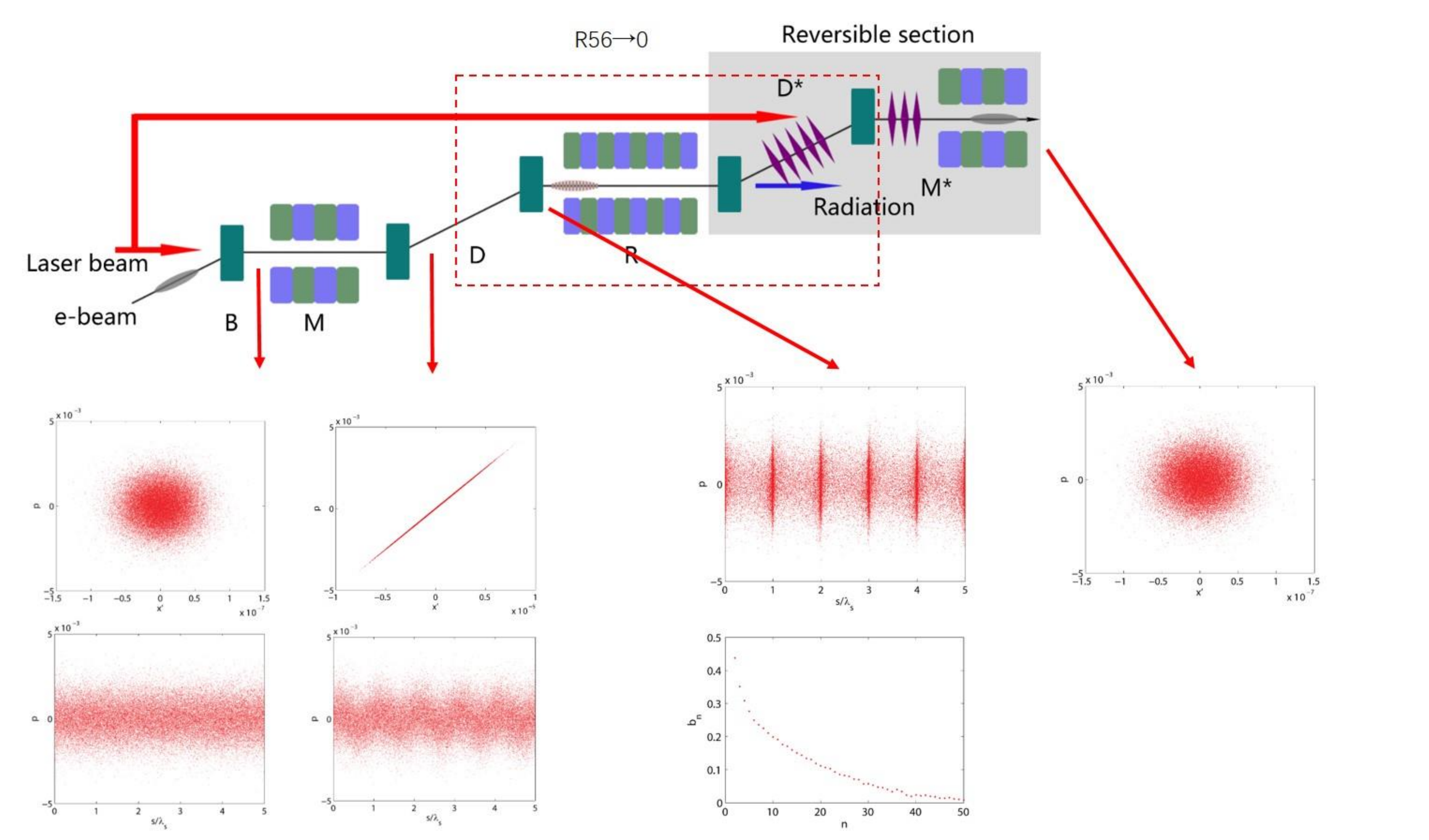
Main Efforts of the SSMB Collaboration

Strong Focusing SSMB Lattice Design



- A dedicated low alpha ring with a circumference of 94m has been designed to suppress several unfavorable effects;
- Further optimization of nonlinearity of the lattice is continuing;
- The longitudinal strong focusing cell is to be implemented;
- Simulation of microbunching will be conducted later.

Reversible Seeding SSMB Lattice Design

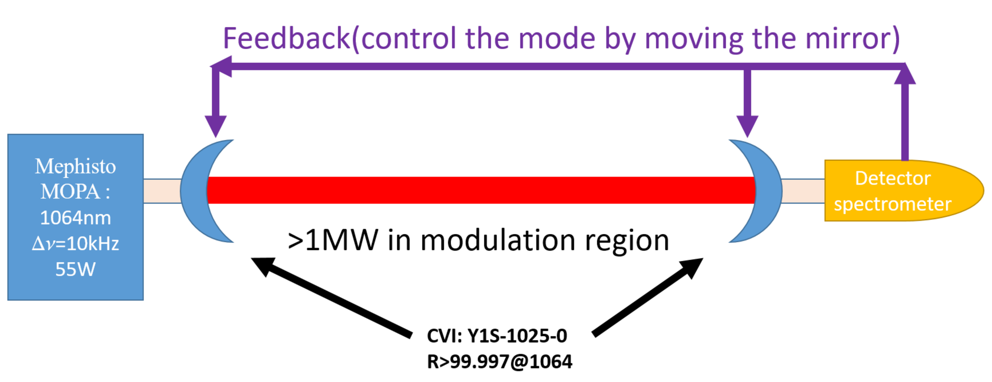


- Electron beam almost recover its original state after traversing the reversible seeding cell without significant increase of energy spread;
- With a seed laser of 270nm, a bunching factor of larger than 0.1 can be realized on the 20^{th} harmonic (13.5nm);
- Further optimization of the reversible cell and design of the overall ring will be done in the following study.

Other Technical Issues

Laser system:

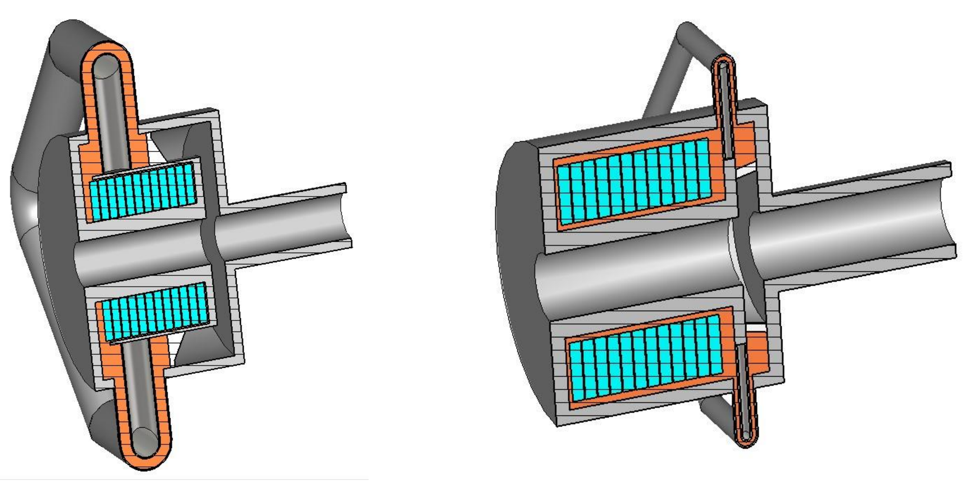
- Ultra narrow linewidth CW laser with optical cavity including feedback system is applied;
- Aim stored power: 1MW .



Layout for modulation laser system.

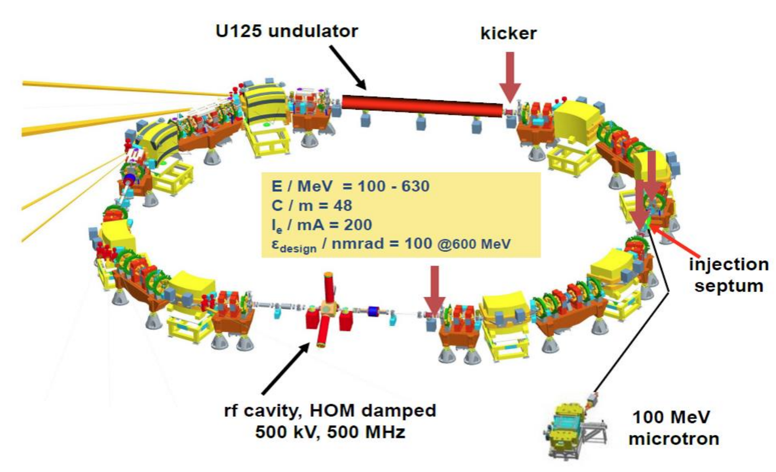
Induction linac:

- Serve as the power supply of the ring;
- Repetition rate of a few MHz and the pulse voltage ~10kV.



Two prelimenary induction linac designs.

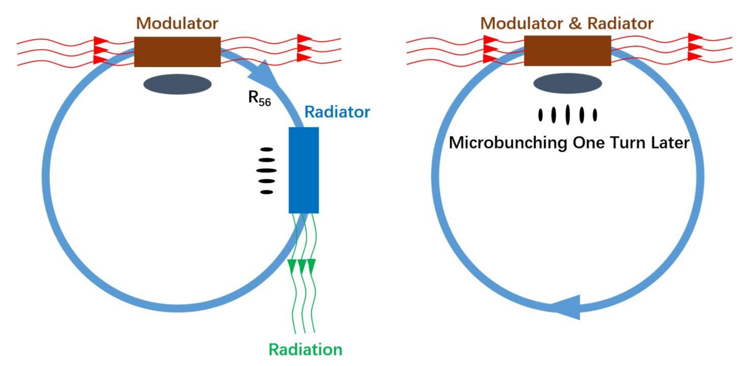
Proof-of-principle Experiment Preparation



Layout of storage ring MLS.

beam energy	250MeV
momentum compaction factor	2×10^{-5}
laser wavelength	800nm
laser peak power	500kW
undulator parameter	2.03
bunching factor one turn later (800nm)	0.25
peak current needed for amplification	48A

An example experiment parameters set.



Two Configurations of the PoP experiment.

- Basic idea of SSMB and related physics are to be investigated in the first PoP experiment;
- After the first experiment, a CW laser system will be implemented for a transition to quasi and true SSMB.

1. Ratner, Daniel F., and Alexander W. Chao. "Steady-state microbunching in a storage ring for generating coherent radiation." Physical review letters 105.15 (2010): 154801.